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RECONDITIONING OF EXISTING ADOBE HOUSING TO MITIGATE THE EFFECTS OF EARTHQUAKES

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SUMMARY

In Peru, as is the case in all of the Andean countries, adobe has been and will continue to be one of the most popular traditional building materials for housing, rural schools and other public buildings. It is estimated that 65% of the rural populations and 31% of city dwellers live in adobe constructions, -predominantly adobe "bricks", and "tapial", or mud-walls.

The reason for this type of construction is undoubtedly its low cost. In the case of rural constructions, the preparation of the necessary materials requires very modest amounts of money, since the materials are found locally at practically no cost, and self-construction is possible. Under harsh climatic conditions, an additional incentive for use of adobe is its good thermal insulation properties.

Nevertheless, the behaviour of adobe constructions during earthquakes, is clearly inadequate. There are so many examples, a memorable one is the 31 may 1970 Perú earthquake, north of Lima, which killed more than 50,000 persons, 20,000 unaccounted for, 150,000 affected and more than 60,000 constructions destroyed, practically all of adobe.

A great deal of research has been carried out with adobe and new technologies are available for the construction of future adobe houses. However, such progress does not address the problem of millions of people in eartqhake-prone areas, who live in existing adobe houses, simply ignoring the possibility that their particular community could be devastated by an earthquake. New recipes for "reinforced" adobe and new building techniques that have been and are being developed, do not in any way solve the problem of the vast number of people now living in precarious adobe housing.

Therefore, it is absolutely necessary to initiate and carry out projects oriented to the reconditioning of existing adobe housing so as to effectively mitigate damage and reduce the number of fatalities caused by future earthquakes. Specifically, the objective is to avoid the rapid collapse of a construction, allowing the habitants enough time to get out and save their lifes. Local materials and simple techniques will be used to lower costs to a very modest sum, so people in poor communities will find it possible to implement the "do-it-yourself" instructions, and to do so without having to depend on external funds or outside experts. The message is "vaccinate your home against earthquakes and save your life", -it must be made clear that although severe earthquakes will probably cause significant damage to their homes, they will still be alive, able to rebuild, and not buried by their home.

1. BACKGROUND

In Peru, and throughout the Andean region, adobe has been and is one of the traditional materials for building houses. It is estimated that in Peru 65% of the rural population and 37% of the city dwellers live in adobe homes (Ref 1), or predominantly adobe; a smaller number use "tapial" (mud-walls).

The reason for constructions of this type is undoubtedly the low cost; in rural areas very little money is required to acquire and prepare the materials necessary to build a home or a school, since these are found locally and self-construction is customary. In cold climates, an additional consideration for its use, is that adobe has good thermal insulation properties.

Nevertheless, the response of adobe houses to seismic demands in general has been poor. Many disasters with high death counts have occurred, mostly in the developing world. The worst case in Latin America this century, with the highest numbers of fatalities and injured, was the 31 May 1970 earthquake, north of Lima in the Department of Ancash, that killed over 50,000 persons, 20,000 unaccounted for and 150,000 injured; and more than 40,000 homes were destroyed, most of them built of adobe (Ref.2).

The poor response to seismic -induced vibrations is a result of inherent mechanical limitations of the material, massive-walls, - fragile and of low resistance, and design defects which do not take into account the mechanical limitations such as: long walls without bracing transversal elements, excessive height from floor to ceiling, and inadequate wall to wall joints and between walls and roof (Ref. 3). After every important earthquake a series of pamphlets and manuals have been published with instructions and recommentations on how to improve the seismic behaviour of adobe constructions. Some of the recommendations contain contradictory appreciations and, in general, most if not all are not based on research which would had led to good results.

Since 1972, the Engineering Department of the Catholic University of Peru (PUCP) has paid special attention to research oriented to improving the seismic behaviour of adobe constructions (Ref. 4, 5, 6, 7, 8 and 9). New materials have been tested as well as different types of construction design to enable new adobe housing to resist seismic vibrations. As a result, new construction technologies, developed for adobe reinforced with reeds has been tested with full-scale models, on the PUCP shaking table installed in the Structures Laboratory, (Ref. 3).

The International Development Research Centre (IDRC) of Canada funded a research project (Ref. 9) at PUCP that studied the response of adobe houses under simulated earthquake conditions. The shaking table at PUCP, the only one of its kind in Latin American, supports a maximum load of 16 tons, moves up and

down and from side to side up to 15 centimeters in each direction. The intensity and characteristics of the movement are selected to match actual accelerograph records of earthquakes in Peru. The purpose of the IDRC-funded project was to develop improved construction techniques and better materials for adobe houses, schools, and public buildings, in rural districts.

As a result of many years of research at PUCP and other Andean institutions, the Technical ADOBE Code for Construction E-080 was adopted in november 1985, and is the norm for all new adobe housing (Ref. 10).

Nevertheless, the success of learning new techniques to improve the seismic response of new adobe housing will not stop future earthquakes from killing thousands of people and damaging beyond repair many thousands of homes all over the developing world. The criteria used to investigate how to build better adobe houses are not directly applicable to existing adobe constructions, which is of course the real problem from the point of view of present vulnerability and risk.

Therefore, it is necessary to pursue projects oriented to reconditioning existing adobe constructions, so as to mitigate damage caused by future earthquake shaking, making use of local materials and simple do-it-yourself techniques, at a cost, so modest, that the procedure can be massively applied. Although important material damage may still occur, the lifes of the habitants will be spared (Ref. 11, 12).

2. OBJECTIVES

The principal objective of the Project is to evaluate and decide on simple strengthenig procedures that will enable existing adobe housing, as a function of site characteristics, and dimensions and type of construction, to be reconditioned to the extent that they will resist seismic solicitations, and guarantee the occupants sufficient time, before collapse, to get out and save their lifes.

The specific tasks, are the following:

a. To establish a methodology to characterize types of existing adobe housing, to determine prevalent shapes and sizes of the majority of constructions. Much of this work has been already done by the Instituto Nacional de Investigacion y Normalización de la Vivienda (ININVI) (Ref. 13).

b. To establish a simple procedure to evaluate the seismic safety of an existing adobe house and to determine if it is necessary to reinforce it or not.

c. To develop simple reinforcing procedures that make use of local materials that can be applied without the help of professionals.

d. To carry out static and dynamic tests on the PUCP shaking table; to evaluate the procedure(s) most appropriate to meet the basic objective of the Project. Some of the results of past research at PUCP on properties of materials and available forces will be very useful.

e. Dissemination of the technology developed with manuals, and video tapes in spanish and quechua as well as by field demonstrations. The message will reach people making use of techniques successfully applied to nation-wide vaccination campaigns. "Simple low cost measures will protect you and your family from possible death, as a result of an earthquake which is likely to occur when least expected". Other possible inducements to be considered are, for example, tax incentives, discounts in price of seeds fertilizer. Pilot demonstration projects, in selected localities will be carried out under different conditions.

3. WORK PLAN AND SCOPE

The project will consist of three stages:

a) Planning, laboratory work and regional workshop.

b) Preparation of video cassetes, manuals and pilot demonstration projects at selected sites.

c) Post-earthquake evaluation, dissemination of results and application throughout developing world.

A. The first stage, to be carried out mostly in Peru, essentially by PUCP, will also involve the Peruvian-Japanese Center for Earthquake Research and Mitigation of Disasters (CISMID) at the National Engineering University and ININVI. The tasks to be performed include.

- Revision of the literature; characterization of adobe constructions on the coast and in the mountains (sierra); classification of typical construction details. Available reports on improved adobe building techniques in Peru, the Andean countries and, Mexico will be analized.

- On the basis of research results of other investigations and prior experience of PUCP, the most promising procedures for strengthening existing dwellings will be selected. The fundamental elements of the experimental program will be defined: number and characteristics of specimens, size, reinforcement details, instrumentation, intensity, displacement and acceleration of the shaking to be applied for dynamic testing.

- Preparation of detailed plans, construction and testing of the specimens on the PUCP shaking table. All activities to be recorded on video tape.

- Test results of the above and corresponding analysis and interpretation will lead to practical recommendations and simple reinforcement procedures. At the same time, the results will make it possible to establish a simple procedure for the evaluation of the seismic safety of an existing adobe dwelling and decide if it does or does not need to be strengthened.

- As a final step, a regional workshop will be organized to present and discuss the work carried out and the results obtained. A preliminary version of the instruction manual will be discussed; it will present, in clear and concise terms, procedures to determine if it is necessary to reinforce the construction and how to go about it.

B. The second phase comprises demonstration projects at different selected sites in Peru and, if possible, in other andean countries. The number of such projects and locations will be decided as a result of consultations, size of adobe-dwelling population at risk, level of vulnerability and hazard potential, and on the different construction characteristics and foundation soil conditions. As a result of the experiences gained in the field with the pilot projects, a multidisciplinary international working group will prepare the final version of the manuals for massive distribution, probably with the help of the media.

At this point, the Final Report on the Project will be prepared and presented.

C. The third phase will be carried out after an earthquake strikes a region where a significant number of constructions have been reinforced as recommended by this Project. A detailed post-earthquake study of the effects of the earthquake will be the real test of the value of this work. If, as is expected, the results conform or exceed expectations, the project will have met its objective, - to save lifes.

As a result of a positive post-earthquake evaluation, or even before, it would make sense to consider similar programs throughout the adobe developing world.

4. DURATION AND BUDGET

This proposal has been prepared by Gianfranco Ottazzi P. and Luis Zegarra C., both Principal Professors at PUCP, at the request of CERESIS, in the spirit of the IDNDR. A principal objective of IDNDR is to save lifes; to reduce the mortality. If

nothing is done to protect the millions now living, studying and working in precarious adobe constructions, in earthquake-prone areas, no matter what is done to improve the quality of new constructions or to adopt policies regarding better use of the land, or to predict events, thousand of fatalities will still be a result of earthquakes, probably even many more than during previous decades, simply because of the ever increasing urban population concentration.

The first two phases will be concluded in three years. This includes the preliminary dissemination of results, the pilot demonstration projects and distribution of manuals and video tape to target areas. This aspect of the project is, of course, a continuing effort, which will be the responsability of local and regional authorities and community organizations.

A detailed project document has to be prepared, with the participation of four to six experts from andean countries, including Peru.

Estimated costs - orders of magnitude - are as follows, for the first two phases:

- Pre-project meeting to finalize detailed project document		$ 8,000
- Honorarium		122,000
1 Project Director (Part time) 750 x 36	27,000	
1 Principal investigators (Part time) 750 x 36	54,000	
1 Technical Assistant full time 400 x 25	30,000	
1 Social Scientist full time 500 x 12	6,000	
- Secretarial services (full time) (Communications, accounting)		12,000
- Dissemination		30,500
Publication costs (Manual) and Video Tapes	14,500	
Distribution	4,000	
Final report (1000 copies)	12,000	
- International Workshop in Lima		23,500
- Pilot demonstration projects (6) $ 10K ea		60,000
TOTAL		$ 297.500

The approximate cost of a third phase - post-earthquake six month evaluation, publications of the mitigation value of the project, including technical seismic response studies of the strengthened adobe constructions, is estimated at $ 50,000.

Dissemination and application in other countries, outside of the andean (Latin American?) region - other then primary distribution of a comprehensive report, is not considered within the scope of the Project.

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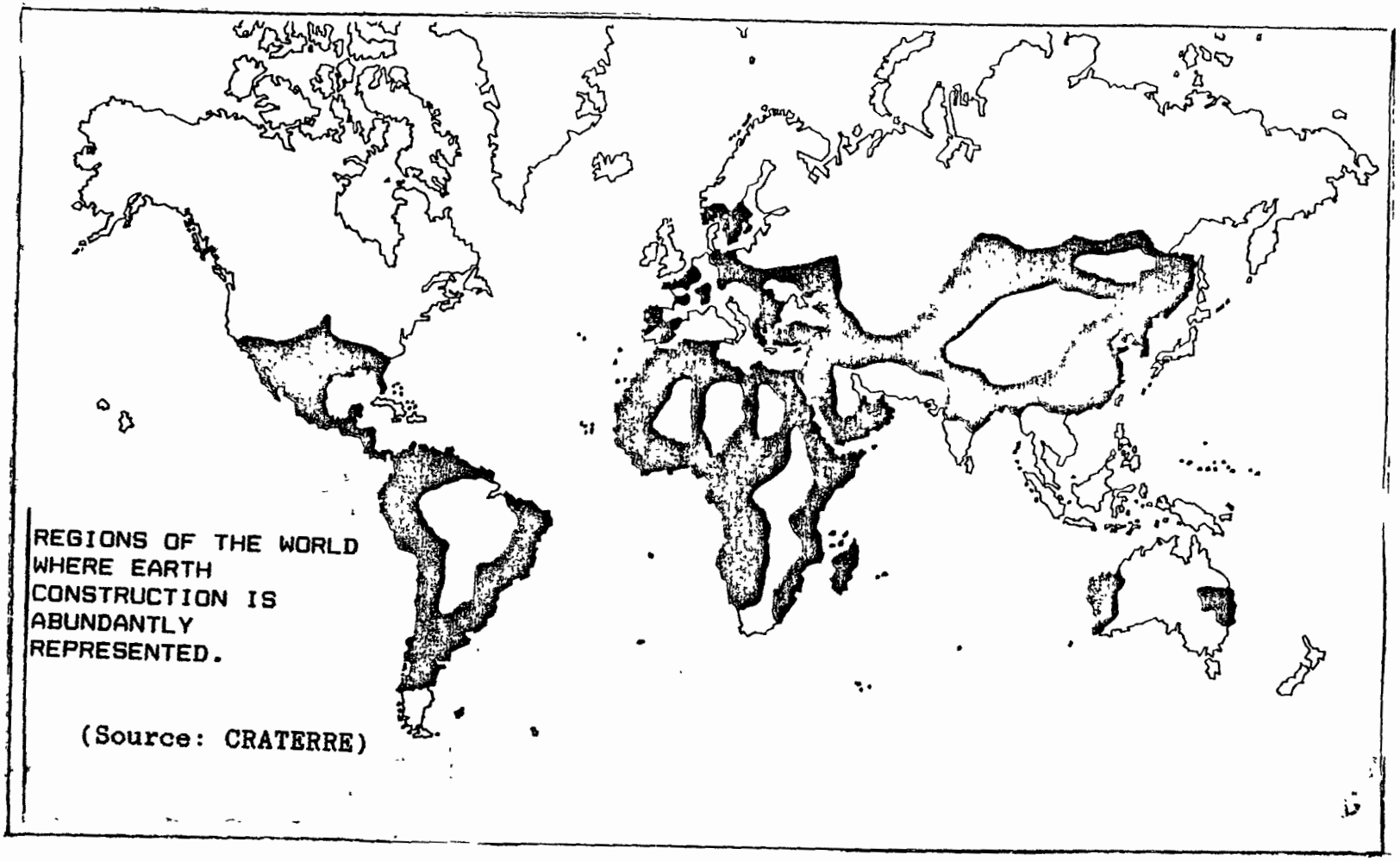

REGIONS OF THE WORLD WHERE EARTH CONSTRUCTION IS ABUNDANTLY REPRESENTED.

(Source: CRATERRE)